



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Chunyuan ("Luis") Chao et al
Assignee: Mosel-Vitellic, Inc.
Title: Dynamically Controllable Reduction of Vertical Contact Diameter Through Adjustment of Etch Mask Stack for Dielectric Etch
Application No.: 10/718,320 Filing Date: 11/19/2003
Examiner: Deo, Duy Vu Nguyen Group Art Unit: 1765
Docket No.: M-15208-US Confirm No.: 1058

Santa Clara, California

COMMISSIONER FOR PATENTS
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ALEXANDRIA, VA 22313-1450

Declaration of Ching-Hwa Chen Traversing Grounds of Rejection Pursuant to 37 C.F.R. §1.132

Dear Sir:

I, Ching-Hwa Chen, declare as follows:

1. My current residence address is 977 Westridge Drive Milpitas, California 95035.

2. OCCUPATIONAL AND EDUCATIONAL CREDENTIALS

2a. I am currently an employee of Mosel Vitelic Corp., an affiliate of the assignee in interest of the above-identified patent application (Mosel Vitelic Inc.). My position at Mosel Vitelic Corp. is Director of Process. In this position, I am responsible for managing essentially all R&D work involving integrated circuit fabrication by Mosel Vitelic in its Northern California research facilities including research and development in photolithography techniques and etch techniques including patterning contact openings to the active layer of an integrated circuit chip. The above-named inventor, George Kovall works at Mosel Vitelic and reports to me. His position is that of Manager of Plasma Etch. One of his

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responsibilities is to oversee developments in the area of reactive ion etching (RIE), including the patterning of interlayer dielectric (ILD).

2b. I personally have approximately 20 years of work related experience in the field of patterning and etching of metal interconnect and dielectric insulating layers of integrated circuits. I have held the position of Director of Process at Mosel Vitelic for the last 6 years. Prior to that, I worked at Lam Research for about 13 years as General Manager and Director of Lam's Metal Etch Business Unit. In both positions I have been intimately involved in process related details including deposition and photolithographic patterning of aluminum stacks and organic and inorganic ARC layers and the chemistries involved in selective etching through them and selective etching of underlying layers.

2c. I received an MS degree in Materials Science from Lehigh University of Pennsylvania in the year 1980. I was awarded a BS Degree in Chemistry from National Taiwan University in 1976

2d. My professional work experience and educational background make me well qualified to opine on the understandings of persons of ordinary skill in the relevant art and at the relevant times as detailed below.

3. DOCUMENTS REVIEWED

3a. In preparing for making this Declaration, I reviewed the following documents:

3.1) Originally filed patent application Ser. No. 10/718,320, filed 11/19/2003 by Chunyuan ("Luis") Chao et. al (hereafter also "the subject patent application");

3.2) Final Office Action (OA) dated of May 19, 2006 for said Ser. No. 10/718,320 and the subsequent Advisory Action of August 29, 2006;

3.3) Applicant's Response After Final August 14, 2006 of for Ser. No. 10/718,320;

3.4) Tsai U.S. Pat. 5,753,418;

3.5) Hui U.S. Pat. 6,514,868; and

3.6) Chien US Pub. 2002/0142610 of Oct. 3, 2002.

4. REVIEW OF FINAL OFFICE ACTION

4a. As I am given to understand, in the Final Office Action (OA) of May 19, 2006, as well as the Advisory Action of August 29, 2006, the examining official (hereafter "Examiner") at the U.S. Patent and Trademark Office (hereafter "PTO") asserted either expressly or by implication that a person of ordinary skill in the art at a time prior to 11/19/2003 (hereafter "critical date") would have been motivated and enabled by the teachings of Tsai '148 alone (or in combination with other prior art documents) to use ARC tapering for forming contact holes of reduced width to the active device layer of an integrated circuit (IC). Also the Examiner asserted that a person of ordinary skill in the art at a time prior to the critical date would have been motivated to combine the teachings of Tsai '418 and Hui '868 and to replace the inorganic ARC of Hui with an organic one such as that of Tsai (Final OA, page 4). This was the general basis, as I understand it, for rejecting the then pending claims as being either "anticipated" or "obvious".

4b. It is to be understood that I am not opining here about the legal "patentability" of any claims, as amended or otherwise formed, and which the Applicant may be presenting concurrently or in the future to the PTO. I am not opining about whether the legal scope of any claim includes limitations of its "preamble" (introductory paragraph) or not. My role here

is that of reviewing the documents from a technical perspective and reviewing the fact-finding conclusions reached by the PTO and not the ultimate legal conclusions. As such, I will not be opining on what would have been legally "obvious" to one of ordinary skill in the art prior to the critical date. Instead I am opining, based on my education, background, and review of the above-stated materials, regarding what an ordinary artisan (at or before the critical date) would have understood from the applied prior art documents and what an ordinary artisan would have been motivated to do or not do in light of such documents but without having hindsight knowledge of the invention set forth in the subject patent application.

4c. Let me begin by providing some background information regarding the etching of organic and inorganic materials such as may be found respectively when working with organic and inorganic ARC layers. It is well known that an organic ARC layer contains carbon-based compounds (more specifically organic polymers) while an inorganic one contains carbonless compounds such as silicon nitride (Si_3N_4) or silicon oxynitride (SiON). The chemistries for selectively etching through these different materials are materially different. Quite often the etch chemistry used for etching through an organic ARC will not etch with the desired results through Si_3N_4 and vice versa; the etch chemistry used for etching through an inorganic hard mask (i.e., an Si_3N_4 ARC) will not etch with the desired results through organic polymer. It can be seen for example that the Hui '868 reference uses a completely different chemistry to etch through its Si_3N_4 ARC compared to what Tsai's '418 uses to etch through its organic ARC to obtain a tapered profile.

4d. Beyond major chemical differences, the mechanical attributes of organic and inorganic ARC materials are substantially different. Si_3N_4 is mechanically harder than a soft Novolak (organic) ARC which is why Si_3N_4 can be referred to as a "hard" mask. (See for

example Hui '868, col. 4, line 18.) The optical attributes of organic and inorganic ARC materials are substantially different. Si_3N_4 and SiON operate on the basis of reflection and phase shift cancellation to obtain the desired anti-reflective properties, while organic ARC operates on the basis of optical absorption. Designers of IC fabrication process may elect to use phase canceling properties of an appropriately thick Si_3N_4 or SiON layer, or alternatively, the optically absorptive properties of organic ARC or combinations of both properties and with varying thicknesses for each depending on desired optical effects (e.g., interference, absorption), on desired mechanical properties and on desired chemical properties. The various permutations of organic and/or inorganic ARC layers are not equivalent and are not arbitrarily swappable one for the next. It is true that at a level on which ARC may be explained to a layperson that one can say, "ARC" is something used to reduce undesired reflections. However, a person skilled in the art understands much more and would not see all ARCs as being equivalent.

4e. So with this introductory background in mind, let me jump directly to the first main point. With regard to the PTO's assertion at the middle of page 4 in the Final OA to the effect that "One skilled in the art ... would find it obvious to use any other ARC including ... organic [in place of Hui's SiN layer 26] ... because Hui teaches that the ARC can be any suitable material having reflective properties ... [and upon using organic ARC the artisan would have] ... a reasonable expectation of success" [Bracketed language and emphasis added]; this assertion is patently wrong and does not at all reflect the thinking of an ordinary artisan. This is so because the ordinary artisan would also understand that Hui's ARC must, above all, function as a hard mask so as to assure creation and maintenance of the tapered profile. The ARCs' optical reflective and phase canceling properties are not a requirement to obtain a tapered profile. However, they may be part of the requirements for

carrying out the preceding lithography, and at a given wavelength, the lithography will dictate the thickness of the reflective ARC layer. In addition, since organic ARC has absorptive properties rather than reflective, the lithographic requirements would require a specific thickness for optimal performance that would most likely be different from the inorganic ARC. Hui intends for the ordinary artisan to understand that she is teaching a "hard mask", meaning not a soft organic one; and that she is teaching a hard mask of hardness that will be amenable to tapered etching with the Cl_2/HBr chemistry described at col. 4, line 8 and one that can maintain its taper even while afterwards being attacked by the etch recipe (not specified) used to transfer the hard mask pattern to the underlying oxide layer (14 of Fig. 4 - see also col. 4, line 18.) Therefore Hui clearly does not teach or suggest replacing her hard inorganic mask 26 (Fig. 4) with a soft organic one. In fact, an organic ARC would fail in her application because it would be too soft and of the wrong chemistry for achieving the desired results. Hence, she directs an ordinary artisan away from considering organic ARC by instead requiring an ARC that has suitable mechanical hardness properties (col. 3, line 50-55).

4f. Moreover, the PTO asserts that there is reasonable expectation of success of etching an organic ARC using the etch chemistry that is intended for Si_3N_4 . The ordinary artisan would have no reasonable expectation of such a success if organic ARC were substituted for the inorganic Si_3N_4 because, as explained above, the different material compositions of organic ARC and of inorganic Si_3N_4 call for different etch chemistries, and as a result, the etch chemistry that works on Si_3N_4 generally would not be expected to work on etching through organic PR and vice versa. In fact, Hui's taught chemistry for etching through SiN most definitely would not etch through an organic ARC.

4g. Based on my education and experience, I am of the opinion that the Attorney arguments presented in the Applicant's Response After Final of August 14, 2006 regarding

Tsai '418 and Hui '868 teaching away from one another to be correct. A person of ordinary skill in the art would see Tsai '418 and Hui '868 as being directed towards completely divergent directions; not only because one teaches organic ARC (Tsai) and the other inorganic ARC (Hui); but also because Tsai '418 is directed to forming field oxide via thermal growth (see Tsai Figs. 5-6) and this has no reasonable connection to the method of patterning through pre-existing oxide as taught by Hui '868. Additionally, I note that Tsai '418 teaches to not etch through oxide (pad oxide 12) while Hui '868 teaches to etch through oxide (dielectric 14). This is another reason why they teach in diametrically opposite directions.

4h. Next, I address the question of whether Tsai '418 suggests itself as useful for forming contact holes to the active device layer of an IC. Once again, I do not opine here about any legal conclusion regarding "anticipation" or "obviousness" or what the correct legal interpretation of the claims should be. Nonetheless, I note that the subject patent application (Ser. No. 10/718,320) clearly directs itself to formation of contact vias to the active transistor level as is abundantly clear from the showing in application Fig. 1 of transistor sources and drains (112,114) separated by the width of the gate poly (120). Also, Fig. 3B of the subject patent application demonstrates that the invention is directed at "densely packed" transistor contacts, given the plot formed by the squares in Fig. 3B (labeled "Dense").

4i. It is clear to me that Fig. 3B of the subject patent application demonstrates a number of "unexpected results". It shows an expectation of failure if one looks only at the results of the 5/1 recipe and the 3/1 recipe because the observed, average via widths (AEI's) are larger than the initial ADI ($0.150\mu\text{m}$ minus a small delta) and because the minimum-to-maximum spreads (vertical bar lines) of the samples is quite large thus making the reliability of consistently forming vias of a given width in mass production highly questionable. The unexpected result comes at the 1/1 recipe mix point where the AEI drops significantly below

0.150 μ m --to about 0.130 μ m-- AND the min-max spread contracts significantly. These are unexpected results in my opinion and I do not see how the Tsai '418 reference could have in any way suggested to the ordinary artisan that such unexpected results could be attained for densely packed contact vias that connect to an active device layer.

4j. Tsai has nothing to do forming densely packed contacts to an active layer. There are a multitude of reasons why Tsai '418 would not suggest itself as being applicable to forming contacts, let alone densely packed contacts. Firstly, Tsai is etching only through silicon nitride (Si_3N_4 layer 14). Si_3N_4 has a relatively high dielectric constant (greater than that of silicon dioxide) and therefore it would not be generally used as the ILD material between the active device layer and the metal-1 layer (layer 145 in Fig. 1 of the subject patent application). The ordinary artisan would not want to be penalized by the large amount of capacitive coupling that would ensue. Instead the ILD will conventionally be composed of a silicon oxide that is free of nitrogen. People in the industry are constantly looking for low-K dielectrics that have an even smaller dielectric constant than silicon dioxide so they can attain higher operating speeds. Tsai '418 does not suggest itself as being related to ILDs.

4k. Most importantly, Tsai's recipe does not etch through silicon oxide; as is evidenced by preservation of layer 12 (pad oxide) in Tsai Figs. 3-4. Note col. 8, line 51 where Tsai says the recipe has "minimum attack" on the pad oxide layer 12. So based on this basic knowledge alone, the ordinary artisan would not only fail to see a connection between Tsai's method and the formation of contact vias through an ILD, the ordinary artisan would be motivated away from considering Tsai because Tsai does not pattern through oxide.

4l. Another reason why the ordinary artisan would be motivated away from considering Tsai is because Tsai is etching through relatively thin nitride 14 (1700Å according to col. 10, line 16) while using a relatively thick stack of organic mask material

(8000Å of PR plus 1500Å of organic ARC per col. 10, lines 32-36 of Tsai). Although Tsai does not say so, it would appear that the total thickness, 9,500Å of organic mask material is important for creating the desired taper in ARC layer 16 using the CF₄ plus Ar chemistry and a high RF power of 800 to 1300W (col. 7, lines 41-64). It would also appear that the total initial thickness, 9,500Å of organic mask material is important for afterwards etching the underlying nitride while using the CF₄ plus CHF₃ chemistry, also at high power of 800 to 1300W (col. 8, lines 34-52). Carbon from the plasma-eroded PR would enter into the mix to create the taper and later maintain the taper when etching through the thin silicon nitride layer 14.

4m. In contrast to the situation of thick PR and thin target layer (nitride) as in Tsai, the situation for the contact layer ILD would be one that calls for a relatively thin PR and a relatively thick oxide layer to etch through. The ILD is thick and made of oxide rather than thin nitride so as to reduce capacitive coupling between the metal-1 layer and the active device layer. The PR is thin to enable photolithographic pattern definition at smaller dimensions and to enable a smaller aspect ratio which, from an etch perspective, is beneficial to ensuring that the smaller aperture widths of the source, drain and gate contacts are opened by etching. (The aspect ratio of the vias would be too large if the PR is made too thick.) Paragraphs [0044]-[0045] of the subject patent application teach an ILD 230 that is 0.1µm or more (in other words thick ILD) and a PR layer of 0.61µm or less (in other words thin PR). Thus it is seen that the situation for etching through contact ILD is very different than etching through thin nitride as in Tsai. The person of ordinary skill would not see any interrelationship or have expectation of success given these substantial differences.

6. Summary

6a. It is my opinion therefore that the Final Office action of May 19, 2006 for the subject patent application contains numerous errors of fact finding as detailed above and it does not present to me a convincing prima facie case of unpatentability based on the prior art that is cited. Tsai '418 does not teach or suggest to the ordinary artisan its applicability to the situation where one is forming contact vias to the active device layer. Tsai teaches to not etch oxide. This directs the ordinary artisan away from thinking of Tsai in the context of contact formation. Tsai is directed to formation of field oxide. This has nothing to do with contact formation.

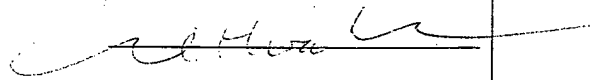
6b. Hui '868 teaches oppositely to Tsai '418 at least with regard to the type of ARC to use (inorganic versus organic) and with regard to whether to etch through oxide or not. So I do not see any rational basis by way of which the ordinary artisan can see to combine the teachings of Hui '868 and Tsai '418. Even if it were possible, Hui '868 explicitly teaches to use a hard, nitrogen-containing ARC mask and this directly teaches away from the use of an organic soft mask (organic ARC).

6c. Fig. 3B of the subject patent application demonstrates unexpected results which are not in any way suggested by the above-cited prior art documents I reviewed. (I do not address Chien '868 in detail above, but note briefly here that Fig. 1C of Chien is directed to a different approach where contact size and alignment is controlled by a nitride etch stop layer 106 and an oxide overhang 114 over the gate poly 104. Preservation of nitride corner 122 appears to be an important issue in Chien.)

6d. In view of the above it my opinion from the basis of the facts at hand that a person of ordinary skill would have no motivation from either of Tsai and Hui (even if combined) to try the contact tapering methods of the subject patent application and to have a reasonable expectation of the surprising results demonstrated by Fig. 3B.

6e. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 18 day of October in the year 2006
at Santa Clara, California.



(Signature)

Ching-Hwa Chen
